DOCUMENT RESUME

ED 458 983 PS 029 946

AUTHOR Fleer, Marilyn; Cahill, Alita
TITLE I Want To Know...? Learning about Science.
INSTITUTION Australian Early Childhood Association, Inc., Watson.
ISBN ISBN-1-87589-050-7
ISSN ISSN-1440-5148
PUB DATE 2001-00-00
NOTE 25p.; Published quarterly. Theme issue.
AVAILABLE FROM Publications Section, Australian Early Childhood Association, P.O. Box 105. Watson, ACT 2602, Australia ($12.52 Australian). Tel: +(02)-6241-6900; Fax: +(02)-6241-5547; e-mail: publishing@aeca.org; Web site: http://www.aeca.org.au.
PUB TYPE Collected Works - Serials (022) -- Guides - Non-Classroom (055)
JOURNAL CIT AECA Research in Practice Series; v8 n1 2001
EDRS PRICE EDRS Price MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS Childhood Interests; Curiosity; Early Childhood Education; Foreign Countries; Learning Activities; *Questioning Techniques; *Science Education; *Science Instruction; Teacher Role; *Teacher Student Relationship; *Young Children

ABSTRACT

Noting that children's questions are usually complex and thereby provide a natural learning context for inquiry-based early childhood education, this booklet focuses on using children's scientific questions as a foundation for planning and creating a stimulating learning environment. Following an introduction, the booklet provides suggestions for supporting children's curiosity by encouraging them to ask questions in their daycare, preschool, or early elementary school environment. Sample child questions are listed with suggested ways for investigating the questions. Information on question-asking by adults includes suggestions for shaping queries to reflect genuine interest and using questions for different purposes. A case study related to children's questions about bees in the garden illustrates how authentic questions can be used as the basis for planning learning experiences, with each question paired with a learning experience to provide an answer. The use of children's questions for planning science educational experiences is explained within the context of an interactive approach to science instruction, growing out of research into children's understanding of a range of science concepts. The teacher's roles in the interactive approach are examined and include monitoring children's interests in the world, recording their ideas and questions, facilitating their investigations, and providing resources. The booklet concludes by noting that following up on children's questions provides them with the opportunity to experience the thrill of working like a real scientist, investigating what matters to them and what is directly related to their world. (Contains 16 resources.) (KB)

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I Want to Know...?

Learning About Science

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Acknowledgements

Special thanks to children, staff, and families at Wiradjuri Preschool Child Care Centre, University of Canberra

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Registered for posting as a publication—
PP232100/00036
ISSN 1440 - 5148
ISBN 1 875890 507
Printed by Goanna Print, Canberra

I Want to Know...?
Learning About Science

Marilyn Fleer and Alita Cahill

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About the Authors

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Introduction

Even when I am very quiet and I creep very slowly the butterflies always fly away. Do they have eyes on their wings or can they see backwards? (Pat, 5 years)

Children ask many questions. Yet how often are these questions used as the basis for planning learning experiences for children? We make detailed observations of children, and identify their social, emotional, physical, and cognitive needs. Then, based on these observations, we plan children's learning experiences. However, social, emotional and physical needs do not exist in isolation and children's questions about the world around them can help us identify and respond to them effectively.

'Do insects have bones?'

Research over the past 15 years has shown how children's questions are immensely more complex and interesting than those posed by adults (Biddulph & Osborne, 1984; Fleer, Hardy, Baron & Malcolm, 1995; Fleer & Hardy, 2001). Children will focus on the everyday in ways that adults are not likely to consider. For example, staff teaching about plants may focus on growing plants from seeds. Yet what is significant to children may well be quite different. A child might ask, *The grass is very dry. How do you put the green back into the plants?* Questions about things significant to children are shown below:

- I think I can see something golden inside that tadpole. Is there a frog inside it ready to come out (hatch)?
- Do insects have bones?
- Can rocks burn?
- Where does the sun go at night?
- Do robots have feelings?
- How does electricity kill you?
- If you fill the tanks of the submarine with water to make it go down, how do you put the air back in to make it go up?
- Is the soil living or dead?

Children's questions are usually complex and cannot always easily be answered. As a result, they provide a natural learning context for enquiry-based education. In order to answer children's questions, a great deal of child-oriented investigation must take place, such as...

- Observing the development of the tadpoles in order to find out if frogs hatch out of tadpoles.
- Collecting different types of rocks and investigating whether or not they can burn.
- Making submarine models and testing them out, as well as reading books on submarines to find out how they float and sink.

The range and complexity of children's questions is not surprising when we consider the intense interest children have in celebrating a new tooth, compared to traditional celebrations organised by adults, such as a Christmas concert or an Easter parade (Dau & Creaser, 1994). Dau and Creaser have shown that events children consider worth celebrating are not necessarily those that adults select when planning in early childhood settings. What is significant to children may well be quite different from what is significant to adults. The interest children show in topics chosen by adults is significantly less than their interest in topics identified by children themselves (Arthur et al., 1998). Children's questions act as a useful guide to determining what is significant and interesting to them.

Although concerns for a child-oriented curriculum versus a theme-based program are well known (Dockett, 1997; Waterton, 1998), staff in early childhood settings may not have considered the range of ways that children's questions can be used to provide a cognitively rich and intensive program for their young charges. In particular, the use of children's scientific questions can be used as a foundation for planning and to create a stimulating learning environment.

Encouraging children to ask questions

There are many different types of questions. For instance, there are *how?* questions, *why?* questions, *what?* questions, *when?* questions and *who?* questions. Some questions are implied by a rise in intonation at the end of a sentence and others are phrased as a question but require no answer (rhetorical questions). This book focuses on what children want to know about their natural and physical world—authentic questions.

Not all cultural groups within Australia place importance on questioning. Children from some indigenous groups may not have had much experience with adults asking questions—and some may think that children who ask questions are challenging an adult's view or authority on the particular subject. However, there are indigenous people who want their children to learn how to ask questions, when to ask questions and to know what sorts of questions to ask (see Fleer & Williams-Kennedy, in press). It is important to find out about—and remain sensitive to—children's experiences, family obligations and etiquette with regards to asking questions.

Children ask many questions in their home environment. Supporting children's curiosity by encouraging them to ask questions in their preschool, child care centre, or school environment is more challenging.

Some suggestions:

- Hang pictures of individual children on a wall chart with the caption *My questions.*
- Hang a wall chart with the caption *Questions we are investigating.*
- Establish sharing time/news time to include a question and answer time, *(does anyone have a question they would like to ask?).*
- Set up a table with paper and textas, labelled *The thinking table.* Children can use this table

Why is the sky blue?

Children can investigate this question by:

- Observing the sky over a week.
- Drawing pictures of the sky.
- Listening to the weather forecast on TV.
- Asking other children their views on the weather.
- Noting cloud cover—inviting a meteorologist into the centre to explain cloud formations.
- Making clouds, (evaporating water—collecting steam on glass—discussing the change of state of matter).
- Passing light through different materials and noting the colours (trying to simulate a rainy day or a bright, sunny day).

to draw, think, and have their ideas scribed—with the view to recording any ideas they have been 'wondering about'.

- Distribute child-sized clipboards with pens for recording their questions and their investigations.
- Provide a question box with a slot for children to post their questions for discussion at group time.
- Hold a parent/family afternoon tea where children share their questions and investigations.
- Staff modelling the asking of questions.
- Give children small audio-recorders so they can interview each other about questions they may have.
- Hang a giant question mark from the ceiling, onto which small cards with questions can be pegged.

Some of the questions children ask can be difficult to investigate. However, if children ask, for example, *Why is the sky blue?*, the adult could ask, *Is the sky always blue?* followed by:

- *Let's go and have a look.*
- *We could draw pictures of the sky each day this week and see if the sky is always blue.*

This activity is likely to encourage further questions from the child and possibly also from other children who become interested in the investigation.

Questions about potentially dangerous elements, such as *How does electricity kill you?* lend themselves well to topics such as *What do we know about electricity? We know it is dangerous ...* Then we could ask *When is electricity not dangerous?*, thus allowing children to investigate the batteries in their toys, or to play with bulbs, buzzers, switches and wires to make circuits. Children could further investigate their questions through books.

Children ask many questions about their environment as they try to make sense of the world. Providing them with routines, such as 'question boxes', which enable them to ask their questions, is the first step towards planning learning experiences in early childhood settings.

The questions adults ask

Question-asking by adults in early childhood settings is a powerful model for children. Educators need to model and explain the purpose and use of questions within the schooling context. Makin (1996) shows the importance of educators being aware of the way they use questioning. Recognising the types of questions we ask is an important first step in planning our interactions in the teaching-learning process. Makin suggests that some questioning may be perceived as merely a 'display' of interest rather than 'genuine' interest in what the child is thinking, knows, and believes. If a teacher is actually seeking information that she/he does not already know, she/he is showing genuine interest, as opposed to asking 'display' questions such as *What colour are your new shoes?* While 'display' questions may start a conversation with children, they are not effective as tools for enhancing children's cognition and understanding.

When staff reflect upon the questions they already use (or do not use), they can move beyond an intuitive level of interaction with children to a more thoughtful level of interaction. Makin (1996) has shown in her research on adult–child interactions that there are at least four categories of interaction. She states that children can be commanded:

- to be *(be good)*;
- to act *(go and get it)*;
- to attend *(look at this one)*; and
- to cognise *(now you have to decide)*.

Makin suggests that it is possible to gain some idea of whether interactions are reflective and

How does electricity kill you?

What do we know about electricity? When is electricity dangerous?

Children can investigate these questions by:

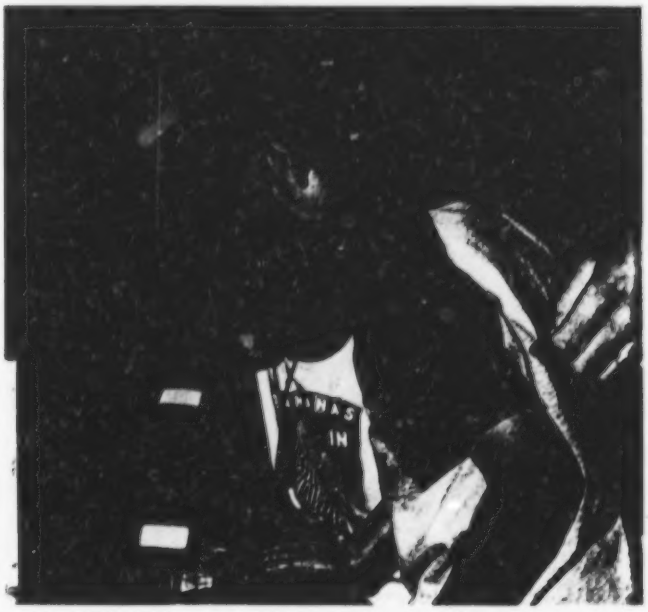
- Looking at which toys need electricity to make them work, including children's torches.
- Making their own torch (simple circuit—batteries and bulbs).
- Making their own toys (simple circuit—batteries, bulbs and different types of switches, buzzers and engines).
- Putting a circuit into the dolls' house.
- Adding more circuits to the dolls' house, using more batteries (packs of three).
- Visiting a power station (or reading books on the topic).
- Discussing safety in the home and the dangers of electricity.

thoughtful or if they focus on commanding children to be, act, attend, or cognise.

Makin's research also indicates that there are different levels of response required of children during adult–child interactions. For example, some interactions are absolute; that is, there is no room for children to negotiate *(glue it here)*. Interactions may also be context-bound; that is, specific to the immediate situation. Often little opportunity is given for children to think about what they are doing in relation to the wider situation; *(this frog looks like the frog we saw in the dam)*. Here the adult offers supportive information such as how it is to be done or how it fits into the wider perspective (Makin, 1996). Finally, interactions can be temporally focused, e.g. interactions which relate to the 'here and now' *(what are you doing?)* versus interactions which deal with past or future events (*do you remember when?* or *what will we be doing tomorrow?*). An analysis of the types of interaction, and hence questions used, is important when thinking about modelling to children.

Different levels of response are required of children during adult–child interactions

Adults can provide a useful running record of how and why they use questioning as they



interact with children. For instance, teachers can preface their questions with an explanation, e.g. 'I am going to ask you some questions about what you know. This helps me find out what you understand. I use this information for thinking about what other things we can do or play with here at preschool/childcare.' For some children the question–answer discourse is unfamiliar, and these explanations help children better understand the culture of schooling.

Other ways that adults use questioning include:

- asking questions to keep the conversation going;
- asking questions as a social greeting *(how are you?)*;
- using questions as a link between ideas and activities in the classroom or centre;
- asking questions as a technique for behaviour management *(Michelle, what do you think about ...?)*.

By talking about 'questions' in context, children are taught about an important form of communication. Children will gain significantly from this metacognitive modelling and will in turn be more likely to engage in question-asking, thus supporting the enquiry-based approach to learning valued in schools and the community.

Authentic questions as the basis for planning learning experiences

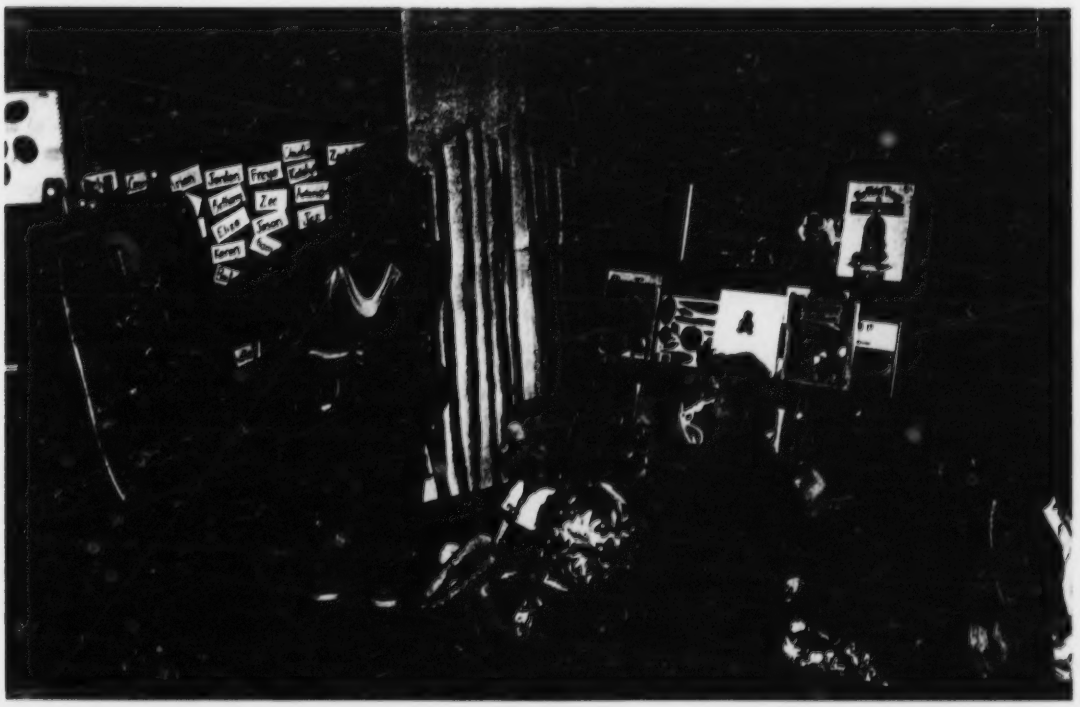
Child care centres, preschools, school, and family day care settings provide a rich environment in which to capitalise on children's curiosity. In these contexts, it is very easy to follow up on children's questions.

The following case study demonstrates one way that staff can plan from children's questions. Alita, a teacher, relates what took place in her child care centre.

Getting started

Alita: It was spring and the children were very interested in all the activity around the flowers in the centre garden—particularly the bees. The children started to ask a range of questions:

Are there boy bees and girl bees?
What do bees eat?
What do bees drink?
How do bees make honey?



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Formulating questions

Alita took the lead from the children and planned how the children could investigate the questions they had about bees.

Alita: After the outside experience, in which children were asking questions, I set up an easel inside and asked the children to think about bees and what they knew. I definitely did not expect them to formulate their own scientific questions at this stage. I did expect the children to give me statements about bees and with these statements I could begin to model questions back to the children. However ...

The hand of a four-year-old child was timidly raised (he rarely spoke up in group discussions). Delicately, I asked him what his question was. He stood up to speak. 'I've got a question,' he said, rather bravely. 'Go ahead... I'll write it down for you,' I said, not expecting what I was about to hear: '*How do bees hurt people?*'

Other questions followed (some arose when we read books, others when we watched the bees):

How many legs do bees have?
What colour are bees?
How many bees live in a hive?
How do bees move around?
How do bees talk to each other?
Where do bees get honey from?
Where do bees live?

How the resource was used

Alita introduced a book she had made (Box 1).

Alita: I decided I could use something friendly, such as this interactive book, to help all the children contribute their emerging ideas about bees. Buzzy the Bee flew from page to page and I recorded all the responses given, using the marker and whiteboard provided. I made sure that the children knew there were no right or wrong answers. This helped the children to feel that their responses were valued.

Box 1

Buzzy's Busy Day
by Alita Cahill

Buzzy set out to start her day. She was flying along but wasn't watching where she was going. BANG ! She flew directly into a tree.

When she woke up, she noticed a spider sitting next to her. 'Hello, what kind of creature are you?' asked the spider. Buzzy began to tell the spider what she was, but she could not remember. Let's help her.

Do you know what Buzzy is?

Next, Buzzy saw Wiggley the Worm. 'Buzzy, why aren't you at work today?' asked Wiggley. Buzzy thought for a minute... Oh no! Buzzy could not remember what her job was!

Do you think you know what Buzzy's job might be?

Later, when Buzzy was playing in a tree, she saw a caterpillar munching lusciously on a leaf. Buzzy was hungry, too, but she could not remember what she was supposed to eat.

Do you know what Buzzy might eat?

It was getting dark. Buzzy wanted to go home, but she could not remember where she lived.

Do you know where Buzzy might live?

Buzzy had been very busy all day. Now her head felt much better but she was very worn out. She looked out and saw that all of the other creatures had gone home to sleep. She could not remember if she was also meant to sleep.

Do you think Buzzy sleeps or not?

Summary of learning experiences

Child's question	Learning experience to answer their question
How many bees live in a hive?	Seek out a multimedia CD on the life of bees (e.g. Dangerous Creatures).
Where do bees live?	Visit to an apiary.
How do bees make honey?	Ask families or friends to help find out.
What do bees drink?	Arrange for a bee-keeper to come to the centre.
What do bees eat?	Visit a resources centre or library to investigate.
Are there boy bees and girl bees?	Search on the Internet.
Where do bees get honey from?	Seek out video/documentary material.
How do bees talk to each other?	Arrange to speak to a bee-keeper over the phone.
How do bees move around?	Take a walk to observe the movement of bees in their natural environment.
How many legs do bees have?	Provide bee specimens for observation.
What colour are bees?	Provide posters and books around the room.

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The interactive process

Alita: At first the children's responses came out as phrases such as 'bees eat honey' and 'bees are in flowers'. As this had been anticipated, I continued by turning their statements around into questions such as:

What a fantastic thing to wonder about, Rochelle. Let's write that down and find out what they eat, shall we? *What do bees eat?*

I asked the children where we might be able to find out the answers to their questions. The first child responded: 'I know where I can find out the answers. I'll just ask my mum; she knows everything!' So that's just what he did. Another child suggested that we 'search the garden for real bees to look at'. One particular child asked if she could 'ring a bee keeper'.

But the suggestions didn't stop there. Later on, two children ran back from a library session with a book that had bees in it, and one said excitedly: 'I found a book with bees in it, we can find some *questions* in books.'

Once all the children began to search for the answers to their questions, the depth of their engagement in the process became very obvious. The more they searched, the more questions they came up with and the more interested they became. The children were following-up on an interest and were learning exactly what they wanted, rather than being given something to investigate or told scientific facts.

At the end of the week the children presented their scientific findings to the group. Their reports demonstrated that the children had really moved forward in their thinking. (see Boxes 2–4)

★★★★★

Children's questions provide a useful framework for planning learning experiences—experiences which begin with what children know and what they are interested in investigating, and then draw upon their ideas for how to find the answers to their questions.

Box 2

Child's question: *What do bees collect from flowers?*

Alita: This child found her answer in a book with the help of an adult. During the final group session this child became quite frustrated with some other members of the group when they tried to tell me that bees collect honey from flowers. She said firmly, 'no, they don't! They collect pollen and nectar'.

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Box 3

Child's question: *How do bees talk to each other?*

Alita: This child rang a bee-keeper and found the answer to her question. She came to the front of the group after she got off the phone and excitedly told the other children that: 'Bees will rub their legs together and it makes a really big noise that tells the other bees where the flowers are, then they do a little jiggle and then, after that, they fly off into the sky and that's called a *swarm*.'

Box 4

Child's question: *Are there boy bees and girl bees?*

Alita: This child found the scientific response for the question in a book: 'There are male and female bees. The male is a Drone and the female is a Worker, but there is also a female bee who stays at the hive called a Queen.'

Finding answers to questions such as how bees communicate or if a tadpole will hatch a frog is a child-focused approach to science. Trying to find out about why butterflies can see you approaching is much more interesting for a child than being introduced to the life cycle of a butterfly through a classroom lesson.

By planning learning experiences which help children answer their own questions, we demonstrate genuine respect for the individuals in our programs.

Approaches to teaching science

Research into the questions asked by children during science learning has shown that they ask questions immediately pertinent to their world. Here are just a few examples:

- Where does a rainbow come from?
- How does a spider make its web?
- Is there steam coming out of the exhaust?
- How do crabs breathe under water?
- Why is grandma's skin wrinkly?

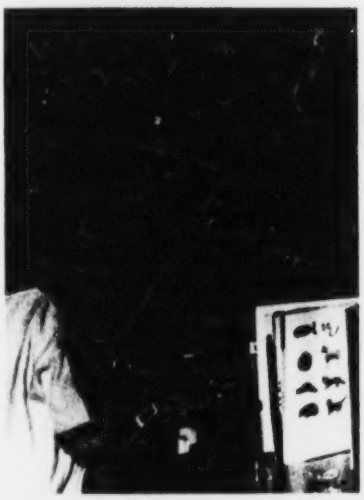
Encouraging children to ask questions has become important in science education. Placing children's questions central to planning is termed an 'Interactive Approach'.

The Interactive Approach to teaching science grew out of research into children's understandings of a range of science concepts. This research, originally conducted with children over the age of eight, demonstrated that children have a range of theories about most of the things in their environment (Osborne & Freyberg, 1985). It was shown that children's emerging ideas—often referred to as 'alternative views'—influence how they make sense of the materials they play with or the information given to them by adults: television, books, etc. (Osborne & Freyberg, 1985).

This research also showed that, once children hold a view about something, it is difficult to change their ideas. For example, if children only have the moon pointed out to them at night-time by an adult, they may begin to associate the moon with darkness. If they have books read to them which reinforce the view that the moon is seen only at night, then they may come to the conclusion that the moon comes out at night and the sun during the day. When they hear stories about the 'sun going down at night', they begin to think about where the sun may go—behind a cloud, under the mountains, or out in space! Changing this evolving theory is very difficult. In fact, research has shown that children can hold alternative views right into adulthood (Fleer & Hardy, in press). They can even pass exams—giving the textbook answers—but still continue to believe in their original theories. In many instances, such ideas (generally not accepted by the scientific community) work very well for them in explaining things around them. As a result, they have no need to question their theories or change their views.

An Interactive Approach to teaching science, devised to find out what children think and to encourage them to ask questions, begins with some sort of exploratory or play session designed or modified to encourage children to express their understandings; for example, providing children with torches, batteries, wires, and bulbs to play with for an extended period. In the process of playing, children will be encouraged to talk about what they know and to ask questions. Their ideas and questions will be recorded and displayed in some way. This is important for helping children see that a *range of views* about the same thing is possible, and provides a natural context for various information to be turned into questions, e.g. when children play with magnets they may think:

- Magnets attract hard things.
- Cold things stick to magnets.

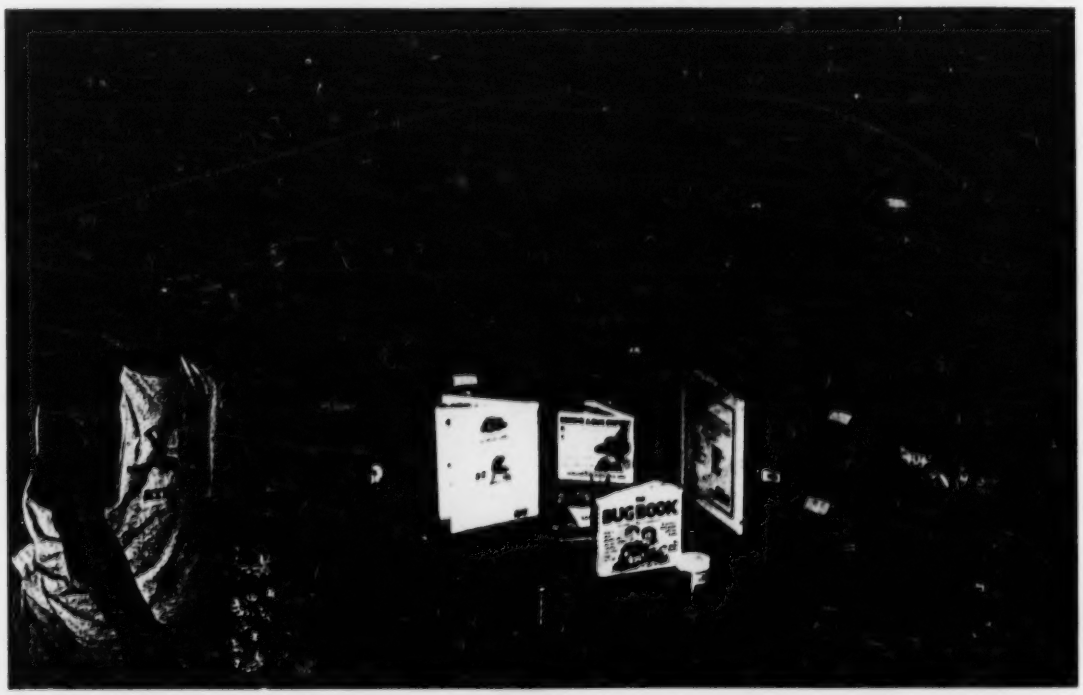


- Magnets are like glue.
- Red magnets push things away and blue ones suck them in.

The teacher can turn each of these ideas into a question:

- Do magnets attract only cold things, or can they attract other things as well?
- Can magnets attract soft things?
- How do magnets attract things?
- Does the colour of the magnet make a difference to what the magnet can do?

The children can then investigate their question. For example, if a child believes that flat batteries weigh less than charged batteries, they are likely to suggest weighing the batteries as a possible investigation. In addition, recording their findings (usually as drawings with scribed notes) and sharing their new ideas provides a rich learning context for the whole group. Research has shown that children are highly motivated to listen to each other's reports—as they too want to know the answers to the questions (Fleer & Hardy, in press).



The teacher's role

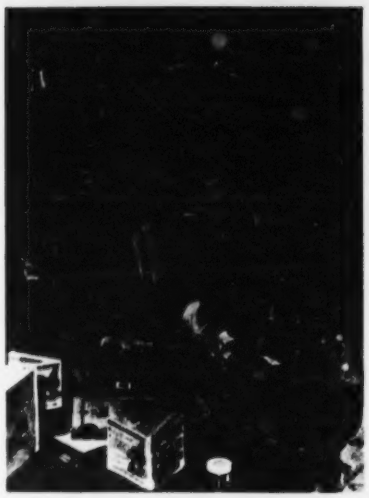
During the Interactive Approach the teacher will take on many different roles:

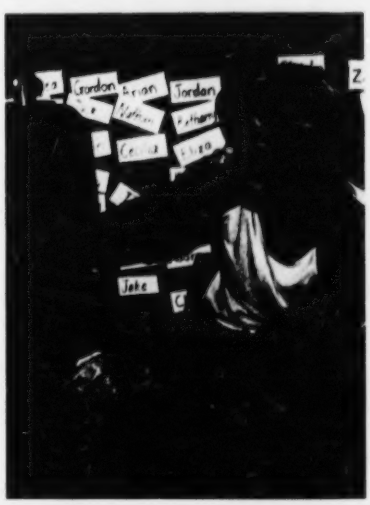
- Monitoring children's interest in the world around them.
- Recording their ideas and questions.
- Facilitating their investigations.
- Providing resources.
- Scribing their findings.
- Organising sharing sessions.

The teacher's main role is to be sensitive to the interests and understandings of the children in the group. It is through *monitoring the children's interest* in the world around them that the teacher is able to seize opportunities to extend children's scientific learning. When a child or a number of children demonstrate an interest, as in the case study on bees, the teacher's role is to become the *recorder*—to note their ideas and questions. Although the teacher may not know the answers to all the questions, this should not deter her/him. The teacher can always act as a *co-learner* with the children.

The teacher can also facilitate the investigations by discussing with the children their ideas about how they could find out the answers to *their* questions (weighing batteries). The teacher could also suggest a range of ways of investigating (ringing up a bee-keeper; setting up an experiment), or provide resources which will help children answer their questions (books).

Overall, the teacher's role is to help children to act scientifically through working together with them to investigate their questions.





Conclusion

The Interactive Approach involves organising opportunities for children to ask questions, and critically examining our interactional style. Helping children answer their own questions provides a cognitively engaging learning environment.

Real scientists investigate problems they do not know the answers to. Following up on children's questions means that children experience the thrill of working like a real scientist. They are investigating what matters to them and what is directly related to *their* world.

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